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Recent Morphotectonics Processes in Lower Valleys of Southern Desert, Iraq

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Abstract

The aim of the study is to identify the type and nature of recent Morphotectonic processes Southern Desert of Iraq, as well as to identify the evidence that confirms these processes, depending on the geological structures. The rivers basins, river networks, faults and folds, as well as longitudinal sections and forms of river drainage patterns, which have been drawn by using topographic maps, in addition to satellite image by using Arc GIS 10.2.

The location of the River Capture or River Piracy and the sites of the rivers basins, which were separated into two parts, were identified. Also geological features with linear direction, forms of formation of plateaus, intersection, ground landing, and flood sediment and river bifurcation were identified. The geology of the region was also used to detect the occurrence of recent Morphotectonic activities.

In this study we find that the upstream of Wadi Abu Ghar basin, was captured by the Sadir and Abu Ghuwair basins. The Sadir and Abu Ghuwair basins were not present at the beginning of the Quaternary period, and these basins were created when a fault occurred with northeast-southwest trend. Most recent studies indicate that the main river streams of the lower valleys were formed during the early Quaternary period.

All geological and geomorphological evidences confirm that Recent Neotectonic movements were happened in this part during the Quaternary period.

Keywords: Morphotectonics; Neotectonic; River capturing; Lower Dry valleys; Southern Desert

Research Highlights

1. We find a recent tectonic uplift (in late Quaternary period), has been detected in the region of lower valleys in the Southern Iraqi Desert.
2. Some of the basins was did not exist at the early Quaternary period, which were later formed after formed a fault towards the northeast-southwest.
3. The upstream of some valleys basins have exposed to tectonic deformations and build up new upstream basins, which formed as a result of tectonic- fault formation, towards North-South.

Introduction

This study is concerned of identifying the most important recent Morphotectonics processes (Morphotectonics and Neotectonics), which influence in geomorphology of the region and their geological-geomorphological evidences. The results of this tectonic activity are represented by sub-surface geological structures. Whereas on the surface of the earth are represented by the topography of land forms of the dry valleys in study area.

Obruchev introduced the term "Neotectonics" defining the field as "recent tectonic movements that occurred in the upper part of Tertiary (Neogene) and in the Quaternary, which played an essential role in the origin of the contemporary topography"[1]. The recent Neotectonic constructions are based on a technique that was proposed and developed by a geophysicist [2,3]. Also the term of "Neotectonics" is defined as the movements of the earth's crust that occur during the Late Tertiary and Quaternary periods [4].

So we find that the definition of Morphotectonics: a rapidly developing direction of geomorphology, designed to reveal the role of tectonic processes in the formation of the region. The relevance of Morphotectonic studies is due to the need to take into account data on tectonics in the restoration of the history of geological-geomorphological development of any region [5].

During this study, many field trips were carried out for the southern desert, its basin valleys and determined the geological-geomorphological processes it is exposed to, especially tectonic processes. The field work has been extended from 2012 to 2016, the latest of which was 20/8/2016.

In order to achieve the objective of this study, the topographic maps of 1: 100.000 and 1:50.000 were used. The satellite image SRTM was also analyses by using Arc Hydrology (ARC GIS 10.2.1) model to derive basins and river networks and extract drainage patterns. The Landsat ETM image satellite in 2013 and the (Erdas Imagine 2014 program) were used to identify the main faults which were compared with the geological map of Iraq 2012.

In addition, geospatial data bases were built in Arc GIS 10.2.1 for analysis, interpretation and spatial comparison of spatial features, and activation processes. Based on the geological-geomorphological evidences, the earth shapes that were affected by recent Morphotectonics are clearly determined.

Also notice that the importance of this study is to explain the

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effect of tectonic movements on the rivers and desert valleys in this desert region which is very important because these rivers are great importance for human life as well as to the rest of the living organisms in such of areas with very dry climates.

Study Area

The area of the study is located in the southern desert at latitudes (29° 47 to - 31° 29- N) and longitude (46° 20- – 44° 00- East) in the area locally named lower dry valleys, such as the rivers basins of Abu Ghar, Al-Sadir, Abu Ghuwair, Al-Kasser, Ash'ali, Hossam, Abu Hazeer, And other smalls. The study area about 24407 km^2, as shown in the Figure 1.

Geological Setting

The geology of the study area is briefly mentioned hereinafter, depending on the available data:

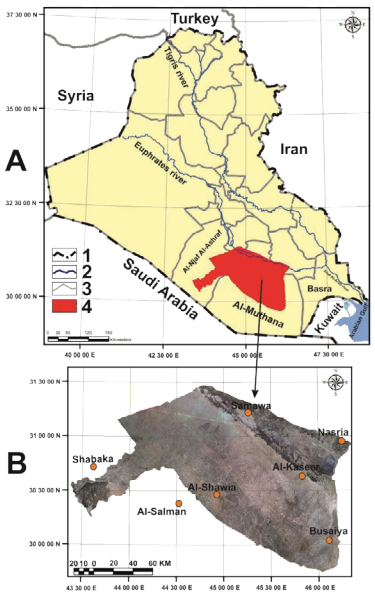

Figure 1: Location of the study area (**A-** Map of Iraq in scale 1:1000000, **B-** Image satellite Landsat ETM+ 2013).

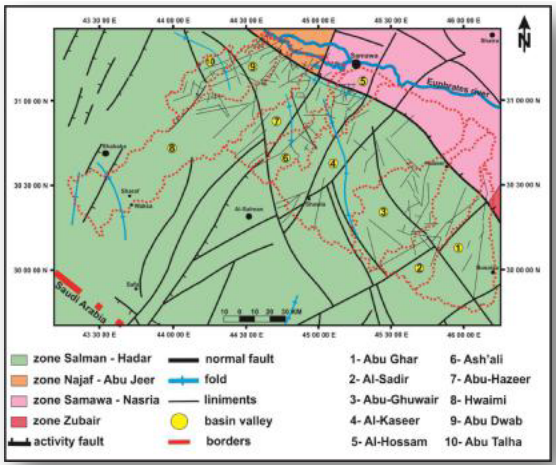

Figure 2: Tectonic map of territory after (Al-Khadimi et al. and use program "Erdas imagin in 2014" Radiation optimization technique the method of extending the contrast and the variance, with use Arc GIS to determination and draw the faults from the satellite image and the tectonic map).

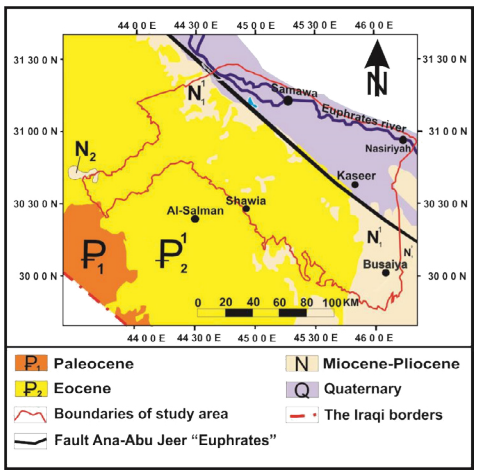

Figure 3: Geological map of the study area after (Sissakian, 2000 and Jassim and Al-Jiburi in 2009).

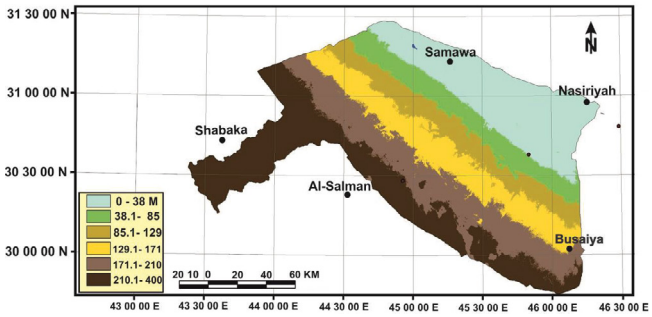

Figure 4: Topographic map (based on the radar image satellite by use Arc GIS10.2.1).

Structural geology

The study area in Southern Desert is located within the Stable Shelf of the Arabian Plate (Figure 2), whereas the other part" Mesopotamian Plain" is located in Unstable Shelf [6-8].

A relatively thin Phanerozoic sequence covers the Precambrian basement complex. The exposed Cenozoic rock units have east and northeast regional dip that does not exceed 2° [9,10].

Stratigraphy

Arranged from base to top, the geological map of the studied area (Figure 3) shows the following sections:

1. **Dammam formation (Eocene):** It is described as nummulitic, chalky and dolomitic limestone; 5 – 18 m thick overlain unconformably overlay the upper strata.

2. **Ghar formation (Lower-Miocene):** This is exposed south of Najaf, south of Samawa, north, south and southwest of Busaiy [11-13]. It is consists of basal breccia or red claystone, calcareous sandstone [9,14] thickness about (10-26 m) [9].

3. **Nfayil formation (Middle Miocene):** It is recently renamed as Nfayil Formation [15]. It consists of 15.2-21 m of fossiliferous marly limestone and green claystone and yellowish brown calcareous sandstone [11,12,14].

4. **Dibdibba formation (Pliocene – Pleistocene):** It consists of

poorly sorted sand, sandstone and gravels of igneous rock [16]. Its thickness about (17-354 m) [14].

5. Zahra formation (Pliocene – Pleistocene): It consists of (3-30 m) white and red limestone [16,17]. Whereas the Quaternary Sediments deposits have a thickness of (6-32 m), composed gypcrete and alluvial fan sediments (Pleistocene), valley fill sediments, depression fill sediments and wind-blown sands (Holocene), also mentioned that fined Terraces was made at this period [14].

Geomorphology

The study area is located in two physiographic provinces, which are the Southern Desert and Mesopotamian Plain. Each of them has its own geomorphological characteristics. The latter is characterized by flat nature with elevation of (5 – 20) m, whereas, the former shows a gradual increase in height towards the west and south. The highest points are 400 m and lowest points are 6 m, respectively (Figure 4).

The Geomorphology of the study area particularly in the major part "Southern Desert" is controlled by three major aspects: climate, lithology and drainage pattern. The present climate according to the data recorded by the Iraqi Meteorological Organization (1941 – 2000), is characterized by mean annual temperature of (24°C to 26°C, mean annual amount of evaporation is 4500 mm. Rainfall occurs during winter months in form of heavy precipitation and rather sporadic, but occurs very rapidly during a short time; mean annual amount of rainfall ranges between 75 – 100 mm. the study area is characteristics by desert semiarid climate [18].

Lithologically the developed drainage pattern has a different density and distribution, in areas where the Dammam formation (Middle-Eocene) is exposed; the density is low, because of the karst features, and the development of immature valleys. On the other hand where the Ghar and Nfayil formations (Lower and Middle-Miocene) are exposed; the drainage pattern is well developed, being of parallel and/ or dendritic type [14,18,19].

The geomorphological units in the territory are represented by Structural – Denudational forms like as plateau and tectonic depressions like as Bahr Al-Najaf, Hor Al-Milih, Sawa Lake, Samawa Saline and Slabiat Depressions, which are developed by strike slip movement along Euphrates Fault Zone (Abu Jir Fault Zone) [18]. Also they have forms Solutional Origin like as Sinkholes and Karst Valleys. The unit of Aeolian origin consists from Dibdibba Sand Sheets, Samawa – Nasiriya Sand Dunes and Nebkhas. Whereas Units of Fluvial Origin consists from Flood Plain, Fluvial Plain and Alluvial Fans.

The alluvial fans in territory have almost typical fan shape, with concave to flattened surfaces, two shapes were recognized: the first group has delta shape, whereas the second group has Finger bird shape. The complex drainage pattern developed in by the alluvial fans system, which trends SW – NE, is similar to the trend of the main valleys [20]. It's clearly observed that the tectonic effect is often interrelated with the development of the alluvial fans. Alluvial Fans are usually developed at places which have Tectonic activity. It is, therefore, possible to see evidence of Neotectonic activity within the alluvial fan succession [21].

Topography

Territory in most of its parts is plateau, whose surface is cut by many desert valleys with internal drainage that have downstream in Slabiat depression, which represented one of the tectonic evidence of the Euphrates fault. The surface of the plateau decrease from the west to east, and is divided into seven categories of slope, the first category (0-38) meters above sea level, which included the low crusades and the western edge at the end of the plain (Figure 4).

The second and third category, which ranged between (38.1-129 meters), included the area of the beginning of the formation of alluvial fans of the flood and the area of pediment, which spread the desert plains. The fourth, fifth and sixth categories, ranging from 129.1 to 210, represented river basin areas at the maturity stage. The last two categories (210.1 - 400 m) represent the upstream of the basins.

Recent Morphotectonic Processes in the Southern Desert – Iraq

Geological structures

The different geological structures control the recent Morphotectonics of any region, and directing their activities, which reflect on the geomorphology of the region. The most prominent geological structures prevailing in the region are:

Faults and folds: In the study area there is a subset of subsurface folds that express the main topographic units on the surface, (Figure 2). Five folds appear in the area, the first at northwest which has 116.5 km long, the second to the northeast has length of 33 km. Whereas third with direction of north-west has a length (41 km), as for fourth towards north west and has length (24 km), the fifth fold towards the north-east and length (8 km).

As for faults, they were identified in the region based on the geological and tectonic maps of Iraq. In addition, using of Arc GIS 10.2 for obtaining information about the area, and their faults distribution within the rivers basins of the valleys.

Geological-Geomorphological Evidence of Neotectonic Processes

By following and studying the stream of valleys in the region, the Morphotectonic evidence of recent tectonic activation was determined as follows:

The emergence of new river basins

By the studying Wadi Abu Ghar basin, which was going his flowing from west to east, at the same time, was completely absent Wadi al-Sadir basin and Abu Ghuwair basin were completely absent. However, recent of tectonic faulting, which researchers believe that originated in the Quaternary period, is based on the evidence of the recent river network and cuts off the ancient river network of Wadi Abu Ghar basin. The emergence of these recent faults has led to the emergence of new river basins and a significant change in the river network of the Wadi Abu Ghar basin, which is now east of the Wadi al-Sadir Basin.

These newest valleys have captured of the ancient river network of the Wadi Abu Ghar basin, due to this recent tectonic activity, which was identified from geological survey maps and analysis of satellite images. While the network of Wadi Abu Ghar, which has lost a part of its river network for the both of Wadi Sadir and Abu Ghuwair.

The most prominent evidence of this is the existence of contact and symmetry between the original valley resources, which now lies west of the valley Sadir, Abu Ghuwair, and with conformably river network in the basin of Wadi Abu Ghar, which is located to the right of the basin Sadir and Abu Ghuwair.

This confirms the occurrence of ground faults in the direction of north-south, which led to the emergence of the basin of Wadi Sadir,

Abu Ghuwair, and separated the upstream of the oldest basin (Wadi Abu Ghar) in two parts. The western part, which has become a part of Wadi Sadir and Abu Ghuwair, while the eastern part is still within the Wadi Abu Ghar basin which is observed from the Figure 5.

This phenomenon was also inferred by comparing the size of the river network within the Wadi Abu Ghar basin, with the left side which became the former of the Sadir and Abu Ghuwair Basin, it turned out that the network was the same size of the capacity and extension.

This recent fault, which has been confirmed depending on the tectonic map. As well as, in satellite images when using the technique of contrast reflection, through which can see and identify the faults and the river network clearly. Also several land distortions have been identified in the region, which have resulted in many tectonic depressions, as well as the occurrence phenomena of river captures.

Processes of rivers capturing

One of the most prominent sites of the river capturing in the study area, of is located between Wadi Sadir and Wadi Abu Ghuwair, (Figure 1, 10A). The Wadi Sadir basin has captured a part of the Abu-Ghuair (diverted captured). As well as Sadir and the Abu Ghuwair valley captured the Abu Ghar basin, whose upstream was following from west to east, and then deviate in its current direction towards the south.

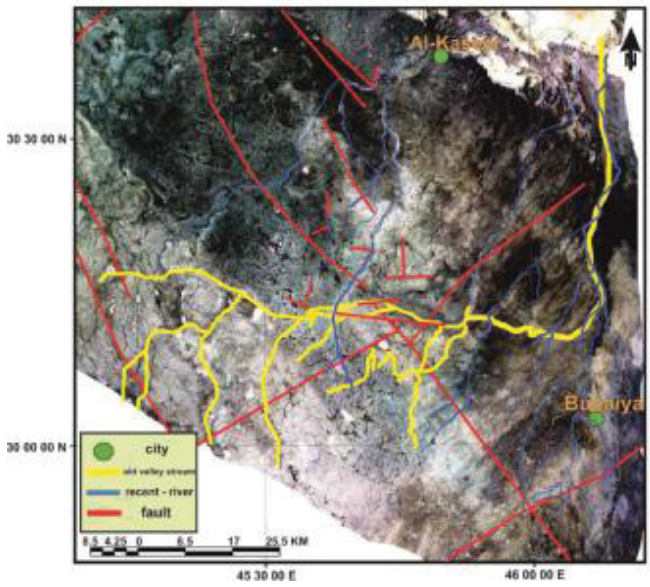

Figure 5: The old and newest river stream of Wadi Abu Ghar (before and after Neotectonics activities in the territory), based on satellite image "Landsat ETM+ 2013" by use Erdas imagin in 2014 and Arc GI.

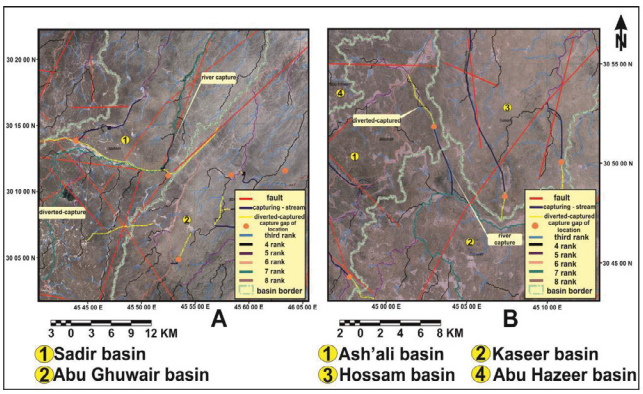

Figure 6: River captures between many of the valleys stream in the basins of territory.

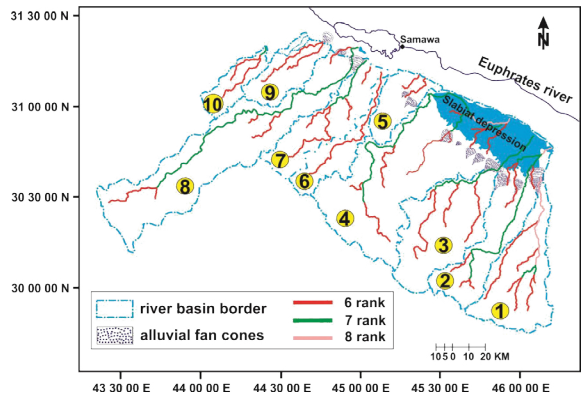

Figure 7: Distribution of alluvial fans in territory.

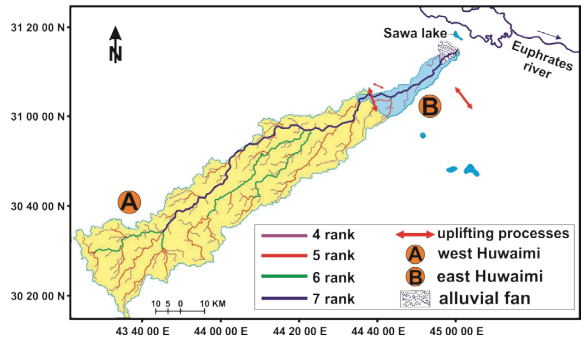

Figure 8: The splits processes of Wadi Al-Huwaimi basin on two basins due to recent tectonic activation.

Another location was identified between the Wadi Al-Kaseer (capture river) and Wadi Ash'ali (diverted captured), (Figures 6A and 6B).

The researchers confirm that the processes that led to the phenomenon of capturing river are an inevitable result of the recent Morphotectonics processes from the Upper Miocene until the Holocene. Which resulted in many geological structures (faults, formation of plateau and depression). When matching the sites of the captured valleys with geological maps and satellite images, it is noted that the valleys match with the directions of those geological structures, especially with the faults.

Reactivation of the valley at stream ends and the formation of alluvial fan

The Euphrates fault is one of the most important factors resulting in tectonic activation in river basins and streams, as it worked on the formation of the Slabiat depression, which ends in it most of desert valleys in the study area. These valleys formed alluvial fans, because of the difference in slope between the area downstream and downstream area of these valleys.

The most prominent valleys that formed alluvial fans from south to north (Abu Ghar, Sadir, Abu Ghuwair, Kaseer, Ash'ali, Abu Hazeer) (Figure 7).

There are eight alluvial fans, which were built at Slabiat Depression,

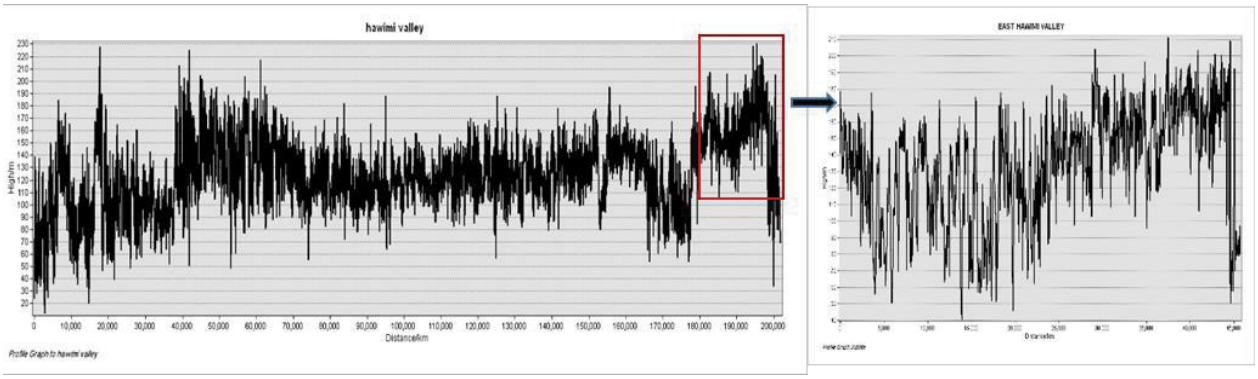

Figure 9: Longitudinal profile of the Wadi Huwaimi (from upstream to downstream).

with two stages and clear differences between the fans in elevation. In the northwestern and southeastern parts of the depression. They differ in their mode of formation, orientation, size and shape. However, Neotectonic activity also has contributed to the development of the depression consequently contributed to their development of the alluvial fans [20].

Change of streams valley

Morphotectonics processes resulted in the changes in the downstream of valleys, the discontinuation of their streams (Cutting the river-bed) and the taking of a new local base, as was the case in the Wadi Huwaimi basin. The tectonic uplifting processes led to the separation of the river network of this valley into two parts, west and east parts. And the occurrence of tectonic Landfall, which formed a new depression which became the new base of the valley at the upstream (west end part). Figure 8 shows that, and the emergence of a new basin keep of the same river network of the old valley, when it was in a uniform course towards Sawa lake. The most things which distinguished:

A. The occurrence of the tectonic uplifting phenomenon, which caused the cutoff of the unified river network of the original valley, and resulted in emergence two separate basins; the western basin of Huwaimi and the eastern basin of Huwaimi. This caused of outages water in the main stream of the valley in its eastern part.

B. The emergence of a tectonic depression within the basin, that has been exposed the tectonic movements. This depression has become the level of a new base for the western part of Huwaimi valley basin.

C. The new tectonic depression can be distinguished from the image satellite (Landsat ETM+ 2013 8 Band).

D. The evidence for separation of the Huwaimi basin in two parts during the Holocene is the presence of alluvial fan created by the valley at its old unified site during Pleistocene.

The eastern basin cannot form alone alluvial fan of this magnitude and size, due to its small area of basin stream about (318.49 km^2), as well as in it's recently of the low slope of (1.6) m/km. While the area of the eastern part about (3406.2 km^2), as well as in it's recently of the low slope of (2.2) m/km. It is noted that the area of Wadi Huwaimi before tectonic activation was about (3724.69) km 2 and a rate of slope was (2.1) m/km.

From Figure 9, we note that the basin of Wadi Huwaimi has been exposed to a tectonic landfall lowering in the first 40 km from upstream, then starts tectonic uplifting of a kilometer in the area between km 40 to km 75, and then continue normally until the kilometer (170). From kilometer (170-180) the stream was exposed to tectonic landfall, the area where the depression was formed the level of a new local base.

Accordingly, the basin was separated into two parts, west and east, when the tectonic activation occurred in the Holocene. That's affected directly in the valley stream from km 180 (downstream) to the upstream at km 200 near Sawa Lake, close of the Euphrates River.

Also we can note that this territory is experiencing continuous tectonic activity. At the final parts of Wadi al-Huwaimi, which is close to the Euphrates River, there was a recent tectonic activation in the Euphrates River stream, the most important; it is the rejuvenation of river stream process which occurs in part of the Euphrates River within this region during the 1930s and 1940s [22-25].

The faulty valleys

When matching the main streams and secondary branches, we find that it they are consistent with the integrity of the main and secondary faults. These faults were named on the valleys name, which took faults as river streams. The most important faulty valleys in the study area (Wadi Abu Ghar Wadi Sadir, Valley Abu Ghuwair, Wadi Abu Hazeer, Wadi Kaseer and Wadi Huwaimi.

Conclusion

This study proved that the region is tectonically active, and that this activation has continued from the late Miocene to the present day. It also provides that the occurrence of a clear period of Morphotectonics activity during the last quarter of the Pleistocene, which represented one of the peaks of Neotectonics activity in the region.

The use of advanced softwares for identifications of faults, rivers network and their main basins, river capture points the most important of which was the captured of Wadi Abu Ghuwair and Sadir (recent valleys) on large parts of the river network of Wadi Abu Ghar basin, places where splits the basins of valleys, as in The splits processes of Wadi Al-Huwaimi basin and alluvial fans, through use software (Arc GIS, Erdas imagin 2014 & GR3 Topcon), have taken a major role in the detection of geological structures and geomorphological phenomena. The field study also taken an important role in confirming our results.

This unique study in Iraq, to determine the forms and date of recent tectonic activity, through the interconnection between the birth of recent geological structures (faults and folds) and their effect on the surface. So notice the importance of the research appear in determining the causes of this geological-geomorphological phenomenon, and then putting up the appropriate solutions for it. The most important of these is the identification and selection of the ideal sites for the construction

of dams on desert valleys, as well as other vital projects that serve the diversity of life and its continuation in these harsh environments.

So researchers suggest using this method in other parts of Iraq and other countries, in order to determine the closest time of recent geological structures, and the geomorphological features.

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